General comments:

This paper presents an analysis of the factors that affect the occurrence of marine heatwaves in the North Sea. A correlation-based K-means clustering approach was used to divide the North Sea into two regions that have different variability in marine heatwave cumulative intensity, and detailed analysis carried out to determine the mechanisms that cause that variability. The paper is well written and presented, and the topic and results are of strong interest.

Response: Thank you very much. We carefully considered each of your comments and suggestions, and we would like to respond to them in the following content.

Specific comments:

Line 97 – should Worsfold et al. (2024; https://doi.org/10.3390/rs16183358) be referenced here?

Response: Thank you for noting this. We will add the reference.

Line 157 – a minor comment, but why include November and May in the calculation of tendency but not March or September? Shouldn't it be calculated either November - March and May – September if including the months surrounding the season, or December – February and June – August if not?

Response: Thank you for this comment. We agree that our description of the SST anomaly tendency window could be confusing. To ensure temporal consistency between the left-hand-side tendency and the seasonally averaged budget terms, we will revise the tendency definition to be computed within the core season: (Feb-Dec) for winter (DJF) and (Aug-Jun) for summer (JJA), normalized by the corresponding time interval. All right-hand-side terms are now averaged over the same DJF/JJA periods. The manuscript will be updated accordingly.

Line 184 – I struggle to relate the text here, which says two distinct temporal patterns, to Figure 1b, which does not seem to show a strong peak at ~6 month period. Perhaps a log scale on the y axis might help?

Response: Thank you for this important and constructive comment. We apologize for not clearly describing the preprocessing applied prior to the spectral analysis. The power spectrum shown in Figure 1b was computed from a 12-month running-mean MHWCI anomaly, which acts as a low-pass filter and was intended to emphasize interannual variability. As a result, seasonal variability is strongly dampened and is therefore not expected to appear as a pronounced spectral peak in this figure. To avoid confusion, we will revise this figure and corresponding texts in the manuscript.

Equation 3 – Is the left brace notation intended? The equivalent equation in the referenced paper uses square braces. Also, I'm not clear why the stationary version of the equation is used rather than the full one?

Response: Thank you for this comment. You are correct regarding the notation. We will revise Eq. (3) to use square brackets for consistency with the original presentation in Takaya and Nakamura

(2001). The wave activity flux formulation adopted here follows the stationary Rossby wave activity flux as defined by Takaya and Nakamura (2001), which is widely used to diagnose the propagation of quasi-stationary Rossby wave energy in seasonal-mean and large-scale circulation patterns. Since our analysis focuses on seasonally averaged atmospheric teleconnections rather than transient wave evolution, the stationary formulation is appropriate for the purpose of this study.

Line 185 – How was the 90% confidence interval calculated?

Response: The 90% confidence level in Fig. 1b was estimated using a chi-square significance test against a stochastic noise background. Specifically, we computed the power spectrum from the detrended monthly MHWCI anomalies (with Hanning smoothing), estimated the effective degrees of freedom, and then derived the 90% confidence threshold from the χ^2 distribution. When the lag-1 autocorrelation is positive (and larger than lag-2), we adopt a red-noise (AR(1)) background spectrum following the standard formulation; otherwise a white-noise background is used. Spectral peaks exceeding this 90% threshold are marked as significant in the figure. We will clarify this procedure in the caption of Figure 1.

Line 211 – 2013 onwards seems a short period to calculate the correlation, even though it is statistically significant. Do any other similar length periods in the record have low correlation?

Response: Thank you for this comment. To address this concern, we calculated correlations using moving windows of the same length as the 2013-2022 period across the full record. The sliding-window analysis shows that correlations remain consistently high positive AMV phase (1994-2013), even when the same short window length is applied. In contrast, correlations are weak as those observed after 2013 (Fig. R1). This indicates that the 2013-2022 reduction is not a typical feature of short windows, but instead reflects a distinct weakening of the relationship. We will add this figure in the supplementary of revised manuscript.

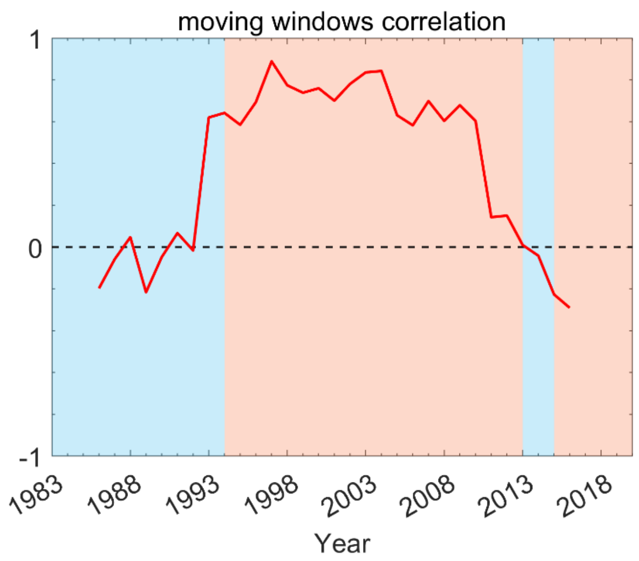

Figure R1. Sliding-window correlation between domain-averaged MHWCI for Cluster 2 during summer and Interdecadal Pacific Oscillation (IPO) index using a fixed window length equal to that of the 2013-2021 period.

Figures using arrow vectors (particularly Figure 7) – Is it possible to make the arrows clearer as their direction is not easy to see?

Response: Thank you for this helpful suggestion. We will improve Figure 7 by reducing the vector density and increasing the arrow size to make the flow direction more easily discernible. In addition, we will simplify the vector representation by using arrow length to indicate current speed and a uniform color for all vectors, which will further enhance clarity and improve the readability of the figure.

Figure 7 – Colour bar for panels a and f uses a diverging colour scale and it would be better to use a non-diverging scale as the scale goes from 0 to 0.02.

Response: Thank you for this comment. We would like to clarify that the colour bars for panels (a) and (f) represent current speed, which is strictly non-negative, and a sequential scale from 0 to 0.02 m s^{-1} is used. These colour bars are placed below panels (a) and (f) and are separate from the diverging colour scales used for other variables. To avoid confusion, we will revise the figure caption to more clearly indicate the range and meaning of the colour scale in panels (a) and (f): (a), (f) Geostrophic oceanic current (vectors, m/s, using a sequential colour scale from 0 to 0.02 m s^{-1})

Figure 7 – Are the MOC and ZOC calculated at a particular latitude / longitude?

Response: Thank you for this question. The MOC and ZOC shown in Figure 7 are not calculated at a single fixed latitude or longitude. Instead, they are obtained by integrating the velocity field across the entire zonal or meridional extent of the study domain, respectively. Therefore, the resulting MOC and ZOC represent basin-integrated overturning circulations rather than transports along a particular section. We will clarify this in the revision.

Figure 7 convergence and overturning circulation colour scales - What direction do negative or positive numbers indicate?

Response: Thank you for pointing this out. We apologize for not clearly stating this in the original caption. In Figure 7, "negative stream function values correspond to clockwise circulation, while positive values indicate counterclockwise circulation". This information will be added to the figure caption for clarity.

Technical comments:

Line 400 – Should it say AMV instead of AMO?

Response: Thank you for pointing this out. You are correct. We will revise the manuscript and consistently use AMV.

Fig 2c and d – Series is misspelt in the titles.

Response: Thank you. The spelling error will be corrected in the revised figure.

Figure 7d, e, i, j – Suggest adding Latitude or Longitude labels on the x axis.

Response: Thank you for this helpful suggestion. Latitude/longitude labels will be added to the x axis in panels 7d, e, i, and j.

Figure 8 – budget is spelt wrong in the title.

Response: Thank you for pointing this out. The spelling error will be corrected in the revised figure.

Figure 9 – Colour bar should be labelled

Response: Thank you for pointing this out. The colour bar in Figure 9 will be labelled with the appropriate unit ($m^2\ s^{-2}$).